

AIRSCOUT: Aircraft Scatter Prediction Software

by Frank Schmähling, DL2ALF



Preface

The use of Aircraft Scatter (AS) to increase distances of amateur radio contacts on VHF and above has been practiced for many years. Especially in Australia the theory and practical use of AS has been described in many articles since the end of the 80s [2].

A new quality in prediction and online surveillance of AS contacts came up with the roll-out of ADS-B in 2006 (see [Wikipedia](#)). The automated, undirected beacon transmissions of aircraft contain position reports which are primary intended to increase air traffic safety, but can be received by any person having a suitable receiver for 1090 MHz. Following the timetable of roll-out, by 2020 all civil aircraft must be equipped with ADS-B. In 2013 most of the civil aircraft used for public transportation are already so equipped. A description of receiving ADS-B signals with a special receiver and a documentation of extensive AS tests in Europe was published in 2006 by DF9IC [3].

The next step was the broadcast of received position reports via the Internet. There is now a large community feeding a couple of web pages allowing other persons to see aircraft positions online on a map. This service is used by flight enthusiasts all over the world and it gives not only the position but also a lot of additional information, like altitude, speed, track etc.

The aim of AirScout is to put all these information sources together in one easy to use tool for amateur radio operators. It provides the following functionality:

- Calculate a propagation path as a great circle path between two QSO – partners
- Calculate a path profile between both QSO – partners using a Digital Elevation Model (DEM)
- Calculate the mutual visibility of an aircraft from both QSO – partners for each point on the path using their elevation and any possible obstruction between them
- Calculate a “hot area” in which an aircraft is mutually visible from both QSO – partners where a reflection is theoretically possible
- Show calculated path and aircrafts in real time on a map
- Predict Aircraft Scatter potential for each single aircraft according to position, track and altitude

The software is free for personal, ham radio related use. It is copyrighted by me, DL2ALF. It has been developed using C# and Microsoft Visual Studio Express. It is not Open Source so far, but might be in the future, if someone wishes to join in the development. It could not have been developed without the great help of Open Source software found on the Internet for almost all the presentation and calculation tasks inside the software. You may use it "as is" without any warranties. For further information see the disclaimer on the info tab. As I am not a skilled software engineer, the software may not fit your expectations for functionality and usability. Your feedback is appreciated, but you should remember that this is a "fun project". The software does not claim to be a scientific tool. It is optimized for practical use and does not contain any attenuation calculations based on the bi-static radar equation.

The name of AirScout is derived from the following:

- The capital letters "AS" are short for the phenomenon of Aircraft Scatter
- "Air" is short for "Aircraft" or "Air traffic"
- "Scout" is a synonym for pathfinder, here: finding a path between two stations

The title photo was taken by me, DL2ALF, and is showing an old DC-3 ("Candy Bomber") used to supply the West Berlin citizens during the Berlin Blockade of 1948/1949. This one is still operational at the Berlin-Schoenefeld Airport and can be booked for sightseeing flights.

The following article is a step by step introduction to Aircraft Scatter theory and a description of the AirScout software itself.

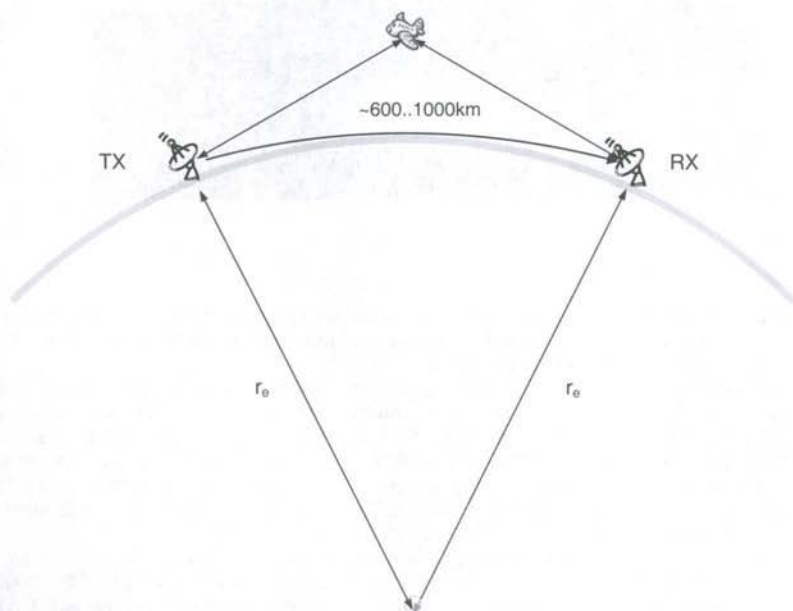


Figure 1: Schematic view of an aircraft scatter QSO

Description of Aircraft Scatter Theory

Introduction

The Aircraft Scatter Theory has been well known since the first RADAR systems came up at the end of World War II. Scattered signals are used to detect an aircraft's position, altitude and speed. If transmitter and receiver are located at different places, the Bistatic Radar Equation ([see Wikipedia](#)) describes the situation very well. The scope of this equation is to calculate the path loss between TX and RX in case of

a non-directional scatter from aircraft. As we know from several experiments, under special circumstances a significant enhancement of the received signal is obtained (20...30 dB). There is an ongoing discussion about whether the enhancement is caused by forward scatter or by reflection. I don't want to join in the discussion and want to make the following statements (valid for the whole document):

1. The following considerations only apply for the period of signal enhancement mentioned above
2. The received signal is considered as reflected by the aircraft
3. There is no calculation included for path losses or possible signal enhancements

The basic view of an aircraft scatter QSO is shown in Fig. 1.

Based on these simplifications we can start now with some theory.

The most basic conditions for the use of Aircraft Scatter are very simple:

1. The aircraft must be in an unobstructed Line Of Sight (LOS) of both TX and RX.
2. The aircraft must be on or very near to the propagation path between both TX and RX

LOS does not mean optical LOS but "Radio"-LOS. Due to the fact that VHF waves are slightly bent back to the earth, the "Radio"-LOS is larger than optical. To compensate this behaviour, the earth radius is scaled up by 4/3 in all related calculations. On an ideal spherical earth surface the LOS distance d can be estimated by:

$$(1) \quad d \approx 4.12 (\sqrt{h_1} + \sqrt{h_2}) \quad \text{where } d \text{ is in [km], } h_1 \text{ and } h_2 \text{ are in [m] above sea level}$$

In reality, the increase of the earth radius is not a constant. It is affected by the current tropospheric situation and, especially at low VHF, is frequency dependant. But this will remain unpredictable forever. Assuming that the maximum cruising altitude of civil aircraft is about 12000m we can calculate the maximum possible distances for typical TX/RX locations (elevated above sea level). Seen from either TX or RX this is shown in the diagram in Fig. 2:

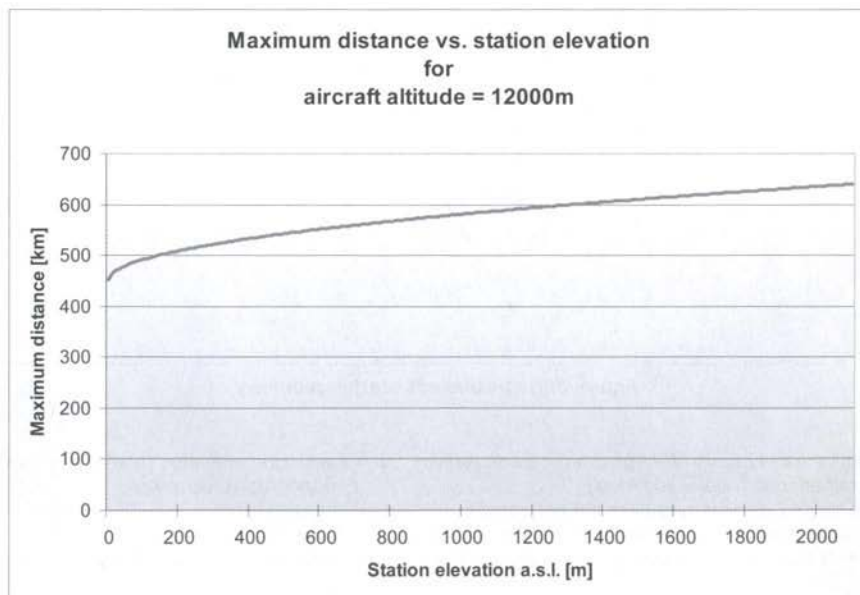


Figure 2: Maximum distance vs. Station elevation

To get the whole path length of an AS connection we have to add the distances for both TX and RX. We can expect a range of 900km (both stations at sea level) up to 1200km (both stations on mountains). In fact distances above 800km seem to be rather difficult and more investigation is needed for these.

Remember that the equation above is only valid for an ideal earth surface. Other limiting factors can reduce the distance dramatically, such as local or distant obstructions. To estimate this influence we need an elevation model (described later on). The following calculations are not a complete description of aircraft scatter theory. They only help to understand how the software works and what it can and what it cannot.

Basic Aircraft Scatter Geometry

To understand the basic key figures of an AS connection we will start with some geometry. Figure 3 is showing the situation at one end of a typical AS connection on a spherical earth (not true to scale).

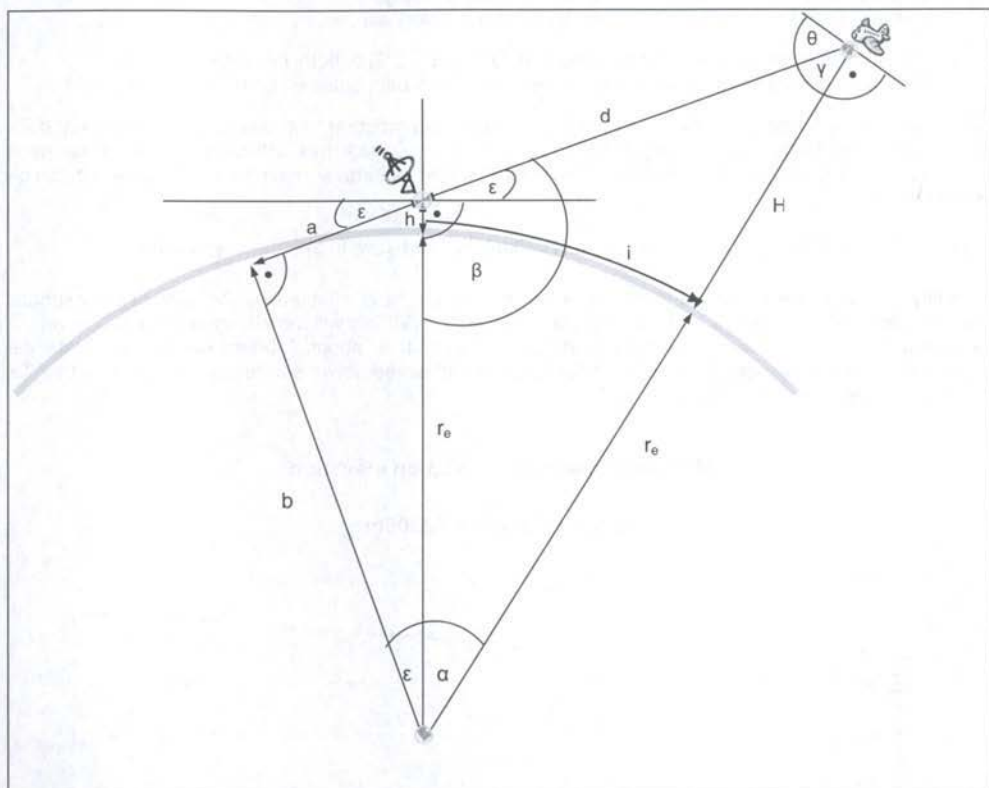


Figure 3: Basic aircraft scatter geometry

Legend:

r_e = effective earth radius ($4/3 \cdot$ geometric Earth radius) h = transmitter elevation (above sea level)
 H = aircraft altitude (above sea level) i = topographic distance
 d = slant range (which is very near but not equal to i for long distances)
 ϵ = elevation angle (of aircraft seen from transmitter's horizontal plane)
 θ = angle of incidence (angle between incoming wave front and aircraft's horizontal plane)

Calculation of Angles ϵ and θ

The two important angles to know are:

1. the angle of aircraft seen from the transmitter's horizontal plane, called ϵ
2. the angle of incidence of the transmitted wave front at the aircraft's horizontal plane, called θ

Figure 4 shows three triangles used to calculate these angles:

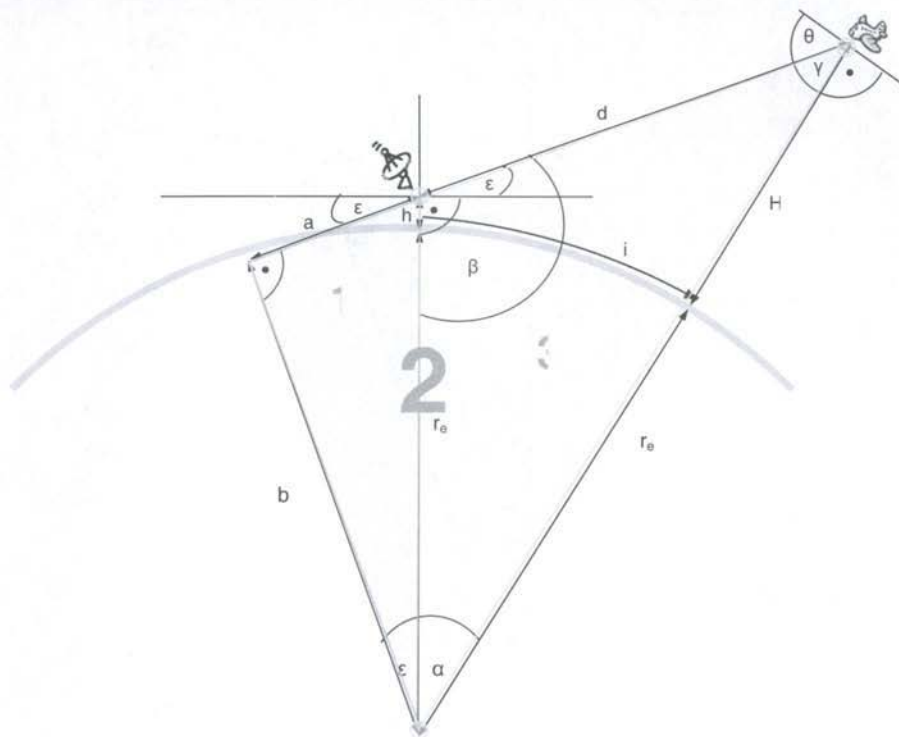


Figure 4: Calculation of angles ϵ and θ

After understanding the geometry overview we can start now with calculations. Assuming that the position and altitude of TX and a distinct aircraft are known, the calculation of angles is possible. Idea and most of the following arithmetic is courtesy of Henning, DF9IC, adapted by Frank, DL2ALF. All formulas are optimized for software programming; some further simplifications might be possible.

Given: r_e, h, H, i

We start with basic the trigonometrical relationships of right-angled triangles (named 1 and 2):

$$(1) \quad a^2 + b^2 = (r_e + h)^2 \quad ; \text{ triangle 1}$$

$$(2) \quad b^2 = (r_e + h)^2 - a^2$$

$$(3) \quad (a + d)^2 + b^2 = (r_e + H)^2 \quad ; \text{ triangle 2}$$

Under the assumption that the earth is a sphere, α is simply the ratio between topographic distance i and complete circumference of earth:

$$(6) \quad \alpha = \frac{i}{r_e}$$

Now we can calculate the slant range d by using the cosine rule in triangle 3:

$$(4) \quad d^2 = (r_e + h)^2 + (r_e + H)^2 - 2(r_e + h)(r_e + H)\cos\alpha \quad ; \text{ triangle 3}$$

$$(5) \quad d = \sqrt{(r_e + h)^2 + (r_e + H)^2 - 2(r_e + h)(r_e + H)\cos\alpha}$$

First, calculate a by replacing b in (3) with (2):

$$(16) \quad \cos \gamma = \frac{a+d}{(r_e + H)}$$

$$(17) \quad \gamma = \arccos \frac{a+d}{(r_e + H)}$$

Now it's easy to get θ finally:

$$(18) \quad \theta = 90^\circ - \arccos \frac{a+d}{(r_e + H)}$$

Calculation of Minimum Usable Elevation Angle $\epsilon_{\min}$

The same calculation as shown above is done for any obstruction caused by terrain on the path between RX and TX to get the minimum usable elevation angle. In Fig. 5 we see an obstructed view from TX with a minimum usable angle. The aircraft outlined in red would be in the LOS theoretically but is obscured by mountains and therefore unusable for AS. The procedure is quite similar to ray tracing which is used to calculate shadows in computer generated graphics (see Wikipedia). With an elevation model the task is now to calculate ϵ for each single step on the whole path. To get $\epsilon_{\min}$ we simply search for the **Maximum** of all ϵ . This represents the highest obstruction on the path respecting the earth curvature and ground elevation of the obstruction. As you can see in Fig. 5 on the path from TX to the obstruction a lower ϵ is possible but makes no sense, as there are no planes at such low altitudes. If the TX elevation is high ($h \gg 0$) and the view is mostly unobstructed, the minimum angle can have negative values as well ($\epsilon_{\min} < 0$).

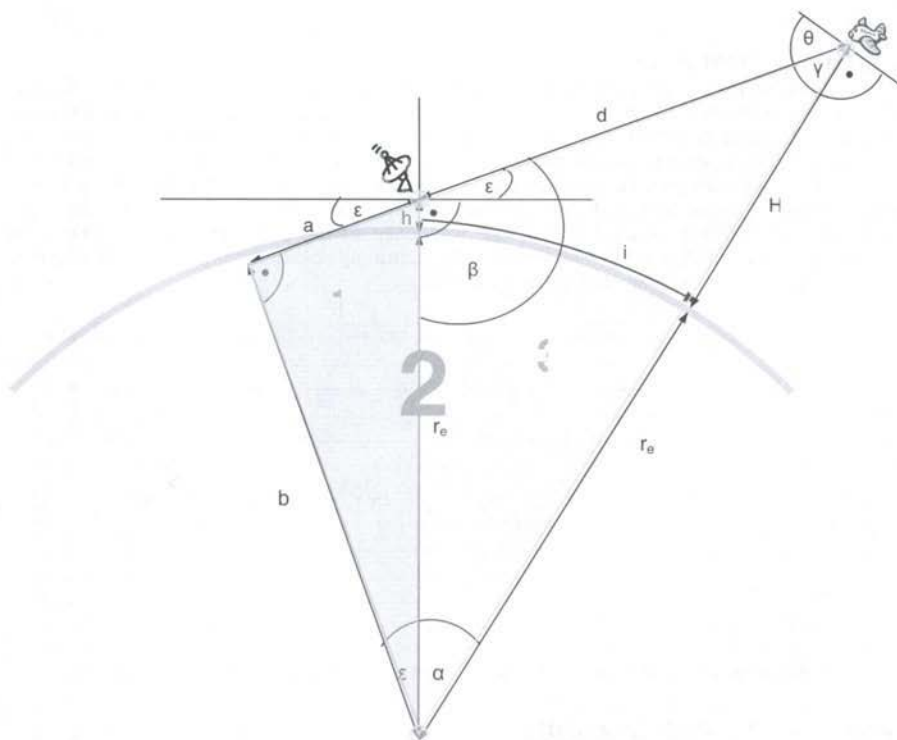


Figure 6: Calculation of Minimum Usable Aircraft Altitude $H_{\min}$

Calculation of Minimum Usable Aircraft Altitude $H_{\min}$

With a given $\epsilon_{\min}$ we can now calculate the minimum altitude $H_{\min}$ an aircraft must have along each step along the whole path.

We start again with calculation on triangle 3.

Given: r_e, h, i, ϵ

Using equation (6) above:

$$(1) \quad \alpha = \frac{i}{r_e}$$

And with known ϵ we can calculate the missing two angles as

$$(2) \quad \beta = 90^\circ + \epsilon$$

$$(3) \quad \gamma = 180^\circ - \alpha - \beta$$

Following the rule of sines we get

$$(4) \quad \frac{(r_e + h)}{\gamma} = \frac{(r_e + H)}{\beta}$$

And solving with respect to H

$$(5) \quad H = \frac{(r_e + h)\beta}{\gamma} - r_e$$

Using the given $\epsilon_{\min}$ we can iterate i now through the whole path and get a $H_{\min}$ for each step, meaning each distance from the location of TX or RX. In other words, we are now able to calculate the minimum altitude an aircraft must have to be in an unobstructed LOS from TX as well as from RX.

Calculation of the "Hot Area"

Doing the above calculations for both ends of the path (TX and RX) and putting both curves on a diagram we can easily see the intersection. This intersection is capped on the upper side by the maximum cruising altitude of civil aircraft (about 12000 m). The resulting triangle is an area in which an aircraft is "seen" from both ends of the path (mutual visibility) and is below the maximum cruising altitude. This area is called the "Hot Area", in which an AS connection is (theoretically) possible. Projected on a flat earth surface it looks like the picture in figure 7. Depending on the elevation of both TX and RX and the given obstructions, this area is usually asymmetric with respect to the half way point of the path. This will assume more importance later on. If the distance is too long or the LOS is strongly obstructed the "Hot Area" might be empty as well. In this case an AS connection is most unlikely.

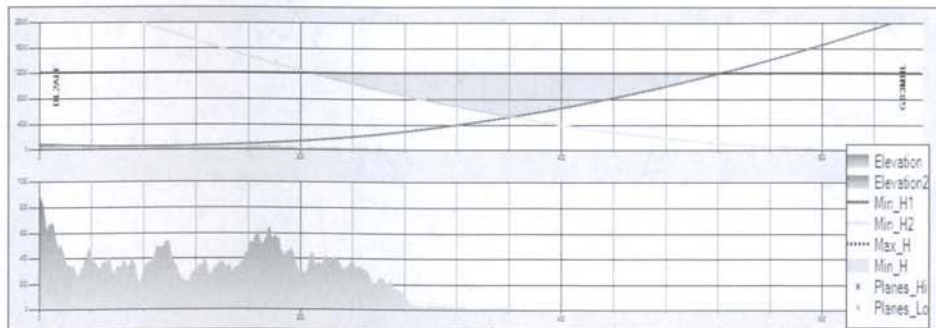


Figure 7: Example of a path calculation with „hot area“, see colour version on p. 60

Basic Parameters for Path Calculation

The basic parameters for path calculation are described below. Since most of the parameters are frequency dependant they can be set for each band.

K-Factor

The K-Factor is used to extend the Earth radius due to the fact that radio waves are slightly bended back to Earth. Set to 1.33 by default, the effect of bending is decreasing with higher frequencies. You can set it to higher values on 144/432 MHz and to lower values on > 5.7 GHz.

F1-Clearance

The space around a travelling wave front is divided in so called Fresnel Zones (see Wikipedia). The most important is the F1 Fresnel Zone. Any obstruction inside the F1 Fresnel Zone will increase the attenuation along the path therefore a minimum clearance must be respected. The Fresnel Zone extent itself is clearly frequency dependant. It seems that the value of the necessary F1 Zone clearance also includes additional frequency dependencies. It is set to 0.6 by default, but you can adjust it to lower values on 144/432 MHz.

Ground Clearance

The ground clearance is intended to be used to correct the altitude values given by the elevation model (primarily the GLOBE model). This may be necessary in respect of existing urban development or vegetation. Since the SRTM3 – data seem to deal already with this fact the parameter is more or less obsolete.

Maximum Distance (from Path)

The maximum distance is used to indicate a maximum lateral distance an airplane can have to consider it "on the path". Since this is not really a constant value along the path it should be replaced by a maximum lateral angle in future.

Using Elevation Models - Introduction

The use of a Digital Elevation Model (DEM) is essential for:

- Getting elevation of the TX and RX locations
- Getting elevations of any obstructions along the path

Fortunately, there are several elevation models available for download on the internet. They contain more or less pre-processed elevation data for almost each part of the earth surface in several resolutions. Most of them are free of charge although restricted to personal use or copyrighted. The DEMs used by AirScout are described below with their advantages and disadvantages.

Global Land One-km Base Elevation (GLOBE)

The GLOBE model is provided by NGDC (part of NOAA) and is one of the most convenient and easy-to-use elevation models. It has a resolution of 30 arc seconds (1 km) and contains very well pre-processed and quality-controlled data. Most of the covered areas are free of copyright and can be redistributed as well. The download is free, users can download compressed data file "as a whole" for any selected area. The file size is moderate. All data can be stored in memory for very quick access. The only disadvantage is the low resolution which does not allow an accurate modelling in the near field of TX and RX.

The use of GLOBE elevation data is mandatory for AirScout; a data file covering Middle Europe is distributed along with the software.

Shuttle Radar Topography Mission 3 arc seconds (SRTM3)

The SRTM is probably the most popular and successful global survey mission. In 2000 a specialized Radar system aboard the Space Shuttle Endeavour performed a near-global scale scan of the Earth surface. The processed elevation data are now used as the basis of almost all elevation models. The data are available in high resolution of 3 arc seconds (roughly 90 m x 90 m). In the current version 2_1 most of the artefacts are wiped out by averaging and comparing with other elevation models. The data files are organized in 1" x 1" tiles which are free for download as Public Domain. The only disadvantage is the large amount of files and data which cannot be held in memory. To get reasonable access, a caching algorithm is necessary. The use of SRTM3 elevation data is optional in AirScout. Due to the huge amount of data the user is asked to download the files himself. The software does support an automatic download from a given source.

Shuttle Radar Topography Mission 1 arc seconds (SRTM1)

SRTM1 data are provided basically the same way as SRTM3 data, but they are only available for the

United States area so far. The data are available in very high resolution of 1 arc second (roughly 30 m x 30 m). The use of SRTM1 elevation data is optional in AirScout. Due to the huge amount of data the user is asked to download (or convert) the files himself. The software does not support a download so far.

Advanced Space Borne Thermal Emission and Reflection Radiometer (ASTER)

The ASTER DEM Version 2 was released in 2011 by METI of Japan and NASA jointly. It is one of the newest elevation models and contains very high resolution data of 1 arc second (roughly 30 m x 30 m). Therefore it is treated as an alternative choice to SRTM1 data. At present time the data are free but not as easy to get as SRTM data. The user must register and fill a free of charge order to get a download link to proceed. There are several disadvantages: As the data seem to be very raw they may contain a lot of artefacts. The amount of data is very large and the data access needs a lot of time even on high performance computers. ASTER data cannot be processed with AirScout. The user is asked to download the files himself and convert them into SRTM1 data using free GDAL tools. As this is somewhat experimental, special ASTER Downloader software (by DL2ALF) is only available on request.

Using Real Time Aircraft Information - Introduction

After calculating of the path between two stations and of the "hot area" we need to set aircraft positions, tracks and altitudes in relation to this. There are several ways to get such information in real time.

Using an ADS-B Receiver

Receiving the ADS-B information send by the aircraft can be done with specialized receivers on 1090 MHz. There are some commercial products available as well as some low cost projects using a DVB-T stick. The problem with both of these approaches is the coverage area: Depending on receiver sensitivity and antenna gain, only an area <200km around the receiver's location can be covered. Taken into consideration that a usual AS distance is above 600km, the coverage area is far from enough. "Best practise" for the use of a dedicated receiver is to feed the aircraft positions to an Internet server and use the help of the community (may not be legal in some countries).

Using a Plane Feed from Internet

The easiest way to get plane position information is the use of an internet feed. There are several community projects of flight enthusiasts who are operating dedicated servers. Most of them are delivering websites which are showing real time aircraft positions on a map. Some of them are proving text feeds for special purpose in addition (often in JSON format). With the help of those text feeds it's easy to supply AirScout software with the information needed.

IMPORTANT: The text feeds are not intended for public use and can be loaded only via "deep link" (see Wikipedia). The use may not be permitted in some countries. Due to legal issues the AirScout user is explicitly asked to accept that he does this on his own risk. The feeds can be changed in URL and data format frequently and without notice. Furthermore it is not guaranteed to be a free service in future.

At present, AirScout can only handle several text feeds from internet.

Essential Data Fields of ADS-B Information

Once we have got plane information via ADS-B we can use the data fields for our own calculations. The following data fields are used:

- Latitude
- Longitude
- Altitude
- Ground speed
- Track
- Type identifier
- Time of transmission (UTC)

Storing aircraft position history

All received positions during the runtime of AirScout are kept in a database. In order to keep the amount of data small, the recorded positions are restricted to:

- An area around the own QTH defined by coverage area (see Options/General)

- A range of altitude suitable for Aircraft Scatter, starting at 5000 m by default and reaching the maximum cruising altitude of a civil aircraft at 12200 m

Regarding each single aircraft, a timeline of positions is stored in memory. A user can fetch the position information for every single point in time. If the requested timestamp is not exactly found in database/is in the future, the position is interpolated/estimated using nearest timestamp found. AirScout is fetching position information from internal database every second using current time when in "Play Mode". If the last position record in database is too old (older than 5mins by default) the estimation is getting too inaccurate and therefore null is returned.

CAUTION: The recording of aircraft positions needs a large amount of memory. There is no mechanism to restrict the memory usage to a defined maximum. Running AirScout for a long time can cause the software to crash.

Aircraft Scatter Prediction Procedure

The next step is to collect aircraft information in an area around the propagation path.

1. Estimate each aircraft's position at this time using last reported position information (lat/lon, altitude, track, time of transmission)
2. Check if aircraft is on or near the "hot path" and aircraft's altitude is above the calculated minimum altitude H_{min} at the shortest distance to path = AS now!
3. If not, calculate any intersection between the "hot path" and aircraft's predicted route in future and check if current altitude is above the calculated minimum altitude H_{min} at the intersection point (using lat/lon track and altitude) = AS in the future, calculate time remaining to crossing (using current position and current speed information)

Aircraft Scatter Operating Procedure

Recommendations for a QSO Procedure

A significant signal enhancement during a single aircraft crossing lasts only about 30 s. Therefore a special operating procedure is necessary. It should be close to the Airplane Scatter Procedure described in the VHF Manager's Handbook [1], ch. 7.6, p. 106. A fixed time schedule (even/odd minutes) similar to a MS procedure may help with random contacts; in a scheduled QSO with AirScout this kind of operating is obsolete. The recommended QSO procedure is described below:

Calling

The QSO starts with one station calling CQ or calling other station by sending both call signs in case of a scheduled QSO. A calling sequence should be kept as short as possible. Do not use alternate calling, only one station is calling, the other is listening until receiving the first calls.

Reporting system

The report system is the standard RS(T) system (e.g. 59, 599).

Reporting procedure

A report is sent when the operator has positive evidence of having received the correspondent's or his own call sign or parts of them. The report must not be changed during a contact even though signal strength or duration might well justify it.

[Standard] The report should be sent at least twice between each set of call signs.

[Contest] Extend the report with additional information requested by the contest rules (e.g. contest exchange or locator). It is recommended to send report and exchange at least twice and locator once followed by a break.

Keep sending information with breaks until you receive an "R" from your QSO partner. Do not send call signs anymore when first copied correctly.

Confirmation procedure

As soon as either operator copies both call signs and a report he may start sending a confirmation. This means that all letters and figures have been correctly received. The message can be pieced together from fragments, but it is up to the operator to ensure that it is done correctly and unambiguously.

[Standard Confirmation is given by inserting an R before the report.

[Contest] Confirmation is given by inserting "RRR" before starting to send report and additional information.

When one operator receives a confirmation message, and all required information is complete he must confirm with a string of R's. When the other operator has received the R's, the contact is complete and he may respond in the same manner. It is recommended to send "73" or "gl" to let the other operator know that you're done.

Requirement for a complete QSO

Both operators must have copied both call signs, the report and a confirmation that the other operator has done the same. This confirmation can either be an "R" preceding the report or a string of minimum three consecutive "RRR".

Arranging a Sked

Aircraft scatter contacts are scheduled in almost all cases. The skeds are arranged via ON4KST chat usually. Good practise is to ask someone for sked with clear arrangements on:

- The frequency for sked
- Who is calling first
- Time left for aircraft to cross the path

Remember: it is OK to arrange a sked but it is not allowed to publish any information concerning the QSO unless you are complete. Here are some examples for ON4KST announcements:

OK:

*"Pse AS test on 23cm. We CQ at 1296.240 ur dir. Next AP in 5mins."
"Tnx fb AS qso es new odx. 73 es gl!"*

OK, but:

*"NC! Sigs faded out. Next chance in 10mins. Wl meep u short before." –
but: **You have to restart the procedure!***

Not OK:

*"Hrd u 559. pse continue clg."
"Mni tnx for 010. 73 es gl!"
"Pse number agn!"*

Hints for Successful Operation

While setting new DX records and contest high scores on the bands please do not forget the ham spirit. Some hints for clean and successful operation:

- Remember that all information for a valid QSO must be sent and confirmed via radio
- Any conversation by any means other than radio communication before you complete invalidates the QSO and you must start over again with the full procedure
- Do not send redundant information that is known to be received by your QSO partner already (e.g. do not send call signs when already called with your call sign by your QSO partner)
- While repeating a message send only requested information by your QSO partner (e.g. do not send grid square twice when requested to send the report)
- You don't need a QSO partner for your first tries. If you are living in Europe you can listen to beacons as well, especially those with high ERP. I had great resultss with GB3MHL on 23cm and with OZ71GY on 2m and 70cm. An SDR with waterfall display helps to find the traces even when they are not audible.
- You don't need to turn your antenna during a QSO. Just beam directly to your QSO partner.
- You don't need to compensate for a Doppler shift, if the aircraft is on or near the path, the Doppler shifts of the incoming and reflected wave front are compensating each other
- You don't need big equipment; any average configuration will do the job. An EME rig will help for sure, but a lot of contacts were made with 20W into a single yagi.
- Try to improve your high speed CW skills. Contacts on CW are working on lower SNR than on SSB but need more time for information interchange. Use faster CW helps to complete the QSO within one aircraft pass.
- Don't give up when an aircraft pass does not cause a significant signal enhancement. Sometimes reflections are unpredictable. Remember the experimental part of our hobby and try again with next aircraft.

Software Manual

Minimum Hardware and Software Requirements

The use of AirScout needs sufficient hardware resources; therefore an up-to-date system is strongly recommended. The following configuration is considered as the minimum:

- Dual core processor 1.2GHz
- 2GB RAM
- 20GB hard disk space
- Screen resolution 1024 x 786 (1280 x 1024 recommended)
- Microsoft Windows XP, Vista or 7
- Microsoft .NET 4.0 (usually already installed on systems > = Vista)
- Internet connection

Installation guide

AirScout comes without an installer with everything in a single ZIP – file. In order to get the software running please do the following:

- 1) Download the ZIP file from the website [4]
- 2) Unzip the file to a directory of your choice
- 3) Check that your PC clock is running synchronized and in the right time zone
- 4) Run AirScout.exe
- 5) Accept upcoming warning that plane feeds are disabled
- 6) Go to "Options/Planes" and enable the "Use Internet feed" option.
- 7) Accept the upcoming warning by clicking the "Accept" button

Users outside Middle Europe must take additional precautions, such as:

- Adjust the covered area according to QTH on the "Options/General" tab
- Specify and download the needed GLOBE elevation data (see later in this document)

To get more accurate path calculations the download SRTM3 elevation data files is recommended. This can be done automatically at any time via "Options/SRTM3/Download data files" after installation.

Directory structure

After the installation is completed the resulting directory structure is the following (all directories must exist!):

<Program directory>	Contains all main components (incl. AirScout.exe)
ElevationData:	Contains all elevation data
GLOBE:	Contains GLOBE elevation data
SRTM1:	Contains SRTM1 elevation data
SRTM3:	Contains SRTM3 elevation data
Database:	Contains all databases, like call signs, aircrafts etc.
Icons:	Contains all icons

Basic Concepts

User Interface

The user interface should be as simple as possible, allowing the user to work with the main window only. In most cases the input of a desired DX call and pressing the "Play/Pause" button would be sufficient.

Therefore the design is made to work with only one path to one QSO partner at one time. For quick change between QSO partners a drop down box with history is available.

All settings are placed in a separate "Options" window which is available only when the software is in "Pause" mode. Separate tabs contain settings for each topic.

Call Sign Databases

The call sign database contains all call sign related information as they are:

- The call sign
- Lat/Lon info
- Locator [6 digit]
- Elevation above sea level
- Antenna height
- Last updated info

Each time above mentioned information is altered, the database kept in memory is updated immediately. The database file is written each time the program is closed.

Elevation Data

The use of elevation data is mandatory for work with AirScout. It is necessary for:

- Getting the elevation above sea level of both QSO partners
- Calculating the path between and find obstructions

Both topics are connected closely with each other and must taken from the same elevation model (regardless which one). It makes no sense to enter the elevation information manually or to "correct" incorrect elevation with increasing the antenna height. Otherwise the calculation of the path and its obstructions will fail. If more than one elevation data source is enabled the search order (e.g. the fallback) for a distinct location is

1. SRTM1 data (if enabled)
2. SRTM3 data (if enabled)
3. GLOBE data
4. set elevation value to 0

The elevation data are kept in several data files according to the type of elevation data.

GLOBE data

File name: mydata.bin, mydata.fmt, mydata.hdr

File location: <Program directory>\ElevationData\GLOBE\

The GLOBE data for Middle Europe (10°W35°N to 30°E60°N) are provided along with the program. If you need other data, you must download the files and place them in the directory manually. Please follow the download instruction as described in the Appendix.

SRTM3 data

File name: *.hgt (e.g. N00E001.hgt)

File location: <Program directory>\ElevationData\SRTM3\

The SRTM3 data are not provided along with the program. You can download them for your covered area by simply clicking "Download data files" on the "Options/SRTM3" tab. The download path is preselected for Middle Europe. If you are located outside the Eurasian Area it is necessary to change the path as described in Chapter "Options". If you have SRTM3 files already on your computer (e.g. using RadioMobile by Roger, VE2DBE) you can simply copy them over the path mentioned above.

SRTM1 data

File name: *.hgt (e.g. N00E001.hgt)

File location: <Program directory>\ElevationData\SRTM1\

The SRTM1 data are not provided along with the program. The use is very experimental and there is no way to download them automatically. If you are living inside the United States, you can download by yourself and copy them into the path mentioned above.

Icons

The plane icons were created from one basic icon to get different colours needed for the user interface.

File name: plane.png

File location: <Program directory>\Icon

You can replace the icon with another one if you don't like it but it should not exceed 40x40 pixels. There are no different icons for each plane category so far.

Covered Area

The covered area is the basic area in which all observations should take place. It is used to:

- Limit the aircraft position recording on database
- Limit the automatic download of SRTM3 data files

The latitude / longitude values can be entered via "Options/General". Please choose an area around your current location; a suitable value would be around 20 degrees in each direction.

Working with precise locations

The precise location of both QSO partners is extremely helpful for a proper path calculation. The use is strongly recommended whenever available. On the other side AirScout should work with a minimum of 6digit Maidenhead locator. To solve this, the software is using the following strategy:

Setting up the location

1. Use an exact location whenever possible. You can get it either:
 - by entering values for lat/lon directly via "Options/Stations"
 - dragging the needles for both stations on the map (when in "Pause" mode)
 - updating via QRZ.COM (the position must match the 6digit Maidenhead locator entered before)
2. Once entered, calculate a new 6digit Maidenhead locator if necessary
3. Store it in the call sign database immediately for further use
4. if an exact location is not known, use the midpoint of the given grid square

Getting the location

There is nothing to do. All calculations are using the lat/lon information stored in the call sign database. This can be either an exact location or the midpoint of a 6 digit grid square.

Future outlook

All locations are stored in a local database so far. It would be a good idea to share information once entered with other users of AirScout. As an internet connection is mandatory to see air traffic, I am thinking about a web service for location updates in future.

Program Main Window and its Elements

See the programs main window and its elements in figure 8.

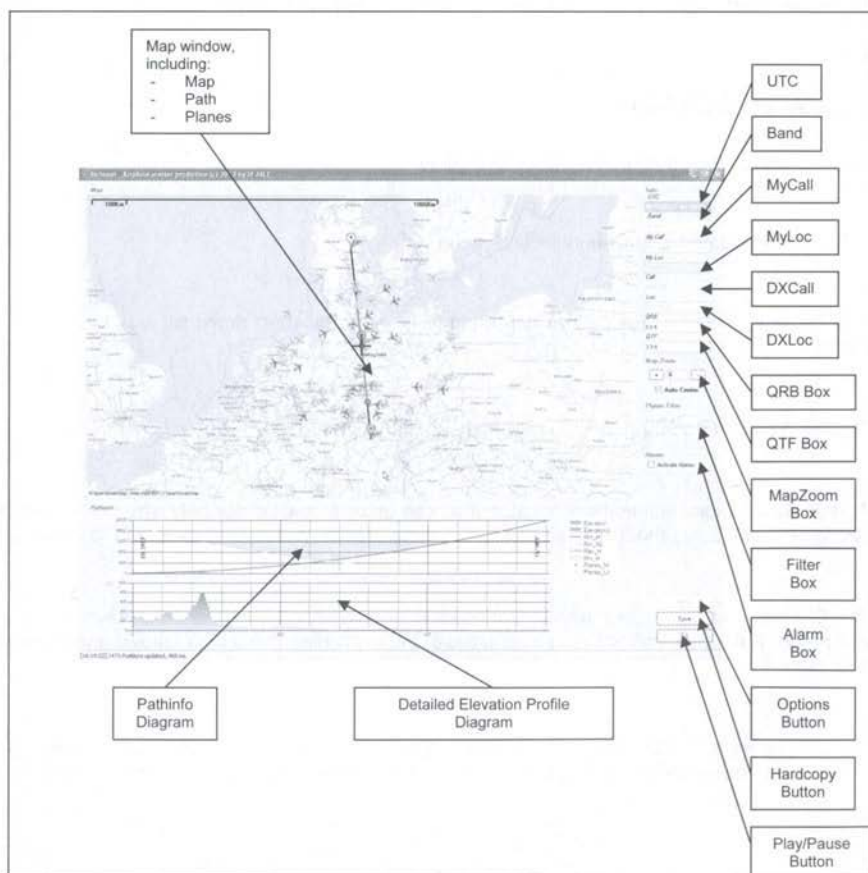


Figure 8: Main window

Map Window

Shows:

- the map (Open Street Map by default)
- the calculated path (in black)
- the "hot path" (in magenta)
- big red marker for MyLoc
- big yellow marker for DXLoc
- big blue marker for midpoint between
- small red marker for begin of "hot path"
- small yellow marker for end of "hot path"
- small blue marker for midpoint of "hot path"
- coloured planes with real time positions

Path Info Diagram

Shows:

- red line for minimum aircraft altitude seen from MyLoc
- yellow line for minimum aircraft altitude seen from DXLoc
- blue line for maximum aircraft altitude (12200m by default)
- magenta triangle for "hot area"
- gray points for aircrafts on or near path with not suitable altitude
- magenta points for aircrafts on or near path with suitable altitude
- green area with elevation profile (mostly not seen because of scaling)
- MyCall
- DXCall

Detailed Elevation Profile Diagram

Is showing:

- green area for elevation profile with auto scaling

UTC

Shows UTC and is updated only when in "Play" mode.

Band

Shows the currently selected band. You can change it using the drop down list box but only when in "Pause" mode.

MyCall

Shows MyCall. You can enter a new call only when in "Pause" mode.

MyLoc

Shows MyLoc as a 6 digits Maidenhead locator. You can enter a new locator only when in "Pause" mode. Green background indicates that the position used is more precise than the midpoint of the 6 digit locator.

DXCall

Shows the DXCall. You can enter a new call or quick choose a previous one via drop down but only when in "Pause" mode. If the new call is found in database, the according position is loaded and shown in the DXLoc box below.

DXLoc

Shows the DXLoc as a 6 digit Maidenhead locator. You can enter a new locator only when in "Pause" mode. Green background indicates that the position used is more precise than the midpoint of the 6 digit locator.

QRB Box

Shows the distance between MyLoc and DXLoc and is updated when in "Play" mode. You cannot enter anything here.

QTF Box

Shows the direction from MyLoc to DXLoc and is updated when in "Play" mode. You cannot enter anything here.

Map Zoom Box

Shows the current map zoom level. You can change it either with the "+" or "-" buttons or using the mouse scroll bar when over the map area. When checking the "Auto Center" option the map is centered to the midpoint between MyLoc and DXLoc when in "Play" mode.

Filter Box

Shows the current aircraft display filter status. You can enter a minimum altitude and a minimum category an aircraft must have to be shown on the map but only when in "Pause" mode. If a filter other than default is selected the box appears in plume colour.

Alarm Box

Shows the alarm status. When checked an alarm is generated when an aircraft is reaching the alarm conditions set in "Options/Alarms".

Program's Options window and its tabs

All options and settings are shown in the "Options" Dialog box.

General

The "General" tab contains information about general settings.

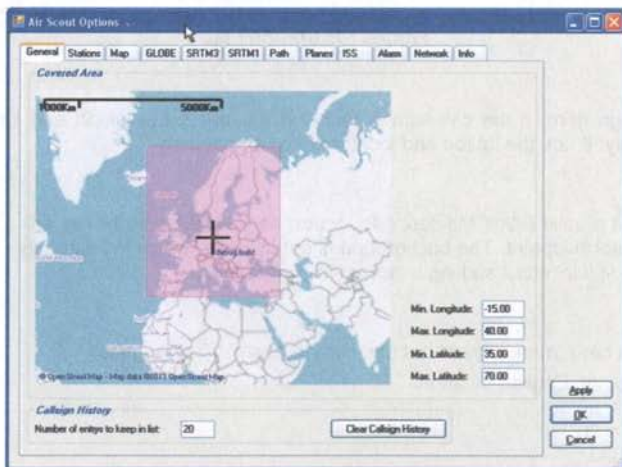


Figure 9: General tab

Covered Area

The covered area is representing the "basic scope" of AirScout. Flight traffic is only recorded inside this area. Furthermore the area is used for automatic download of SRTM3 data files. You can adjust the area by entering numeric values in the boxes on the right.

Call Sign History

The call sign history keeps the call signs recently entered in the DXCall boxes. You can set the maximum number of entries (default = 20) and you can clear the history by pressing the according button.

Stations

The "Stations" tab contains information about the two QSO – partners. Normally, it is sufficient to fill in a

call sign here. If the call sign is found in database, all other information is updated automatically. Green background indicates that a precise location is available. If the call sign is unknown, the update strategy depends on which field is filled (see below). The description of the fields and buttons is valid for both "My Station" and "DX Station".

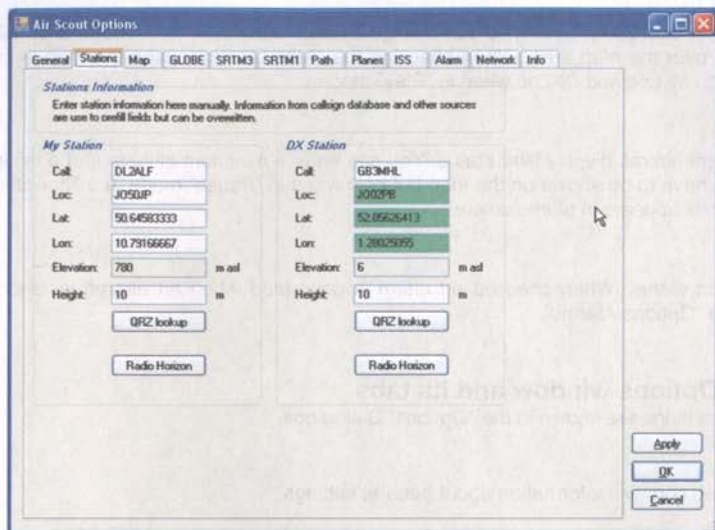


Figure 10: Stations tab

Call

Enter a valid call sign here. If the call sign is found in database, the lat/lon and locator information is updated automatically. If not, the lat/lon and locator boxes are cleared.

Loc

Please enter at least a valid 6digit Maidenhead locator here. The lat/lon boxes are updated with the coordinates of the locator midpoint. The background is set to white, which indicates that no precise location is available. 8 or 10 digit locator handling is not yet implemented.

Lat

Enter valid Latitudes here (manually, do not use copy & paste). The range is:

Format: floating point, English notation

Minimum: -90 deg = 90°S

Maximum: +90 deg = 90°N

Example: 10.6458333

A green background indicates that this is a precise location.

Lon

Enter valid Longitudes here (manually, do not use copy & paste). The range is:

Format: floating point, English notation

Minimum: -180 deg = 180°W

Maximum: +180 deg = 180°E

Example: 10.9716667

A green background indicates that this is a precise location.

Elevation

It is showing the elevation of the station in meters above sea level. You cannot enter an elevation here. The value is updated according to the current elevation model whenever the location is changing.

Height

Enter the antenna height of the station in meters here. A default value of 10 m is used when the exact height is unknown. Do not correct any elevation incorrectness with the antenna height as the resulting elevation + antenna height does not fit the path calculation.

QRZ lookup

The QRZ.com lookup is an easy way to get exact location if there is an entry in their database. To make sure that the location is correct, you must enter a valid locator in the loc box. When the button is pressed AirScout is trying to get the information from the QRZ.com website. If found and the location does fit into the locator in the locator box, the location information is updated. In all other cases an error message will occur.

Radio Horizon

The radio horizon is calculated from the current elevation model in 1° steps around the station. The calculation is strongly influenced by the selected elevation model and the precise location. Therefore it does not make sense to use it with the locator midpoint only. To get the diagrams filled, choose the type of diagram (Cartesian/Polar) and press the calculate button.

The **Minimum Elevation Angle** shows the minimum usable elevation in each direction around the station. The value should be 0 for an unobstructed view and >0 if any obstruction is in sight.

The **Horizon Distance** shows the distance to the according obstruction. For an unobstructed view the distance should be equivalent to the radio horizon as a theoretical maximum and should be nearer if any obstruction is in sight.

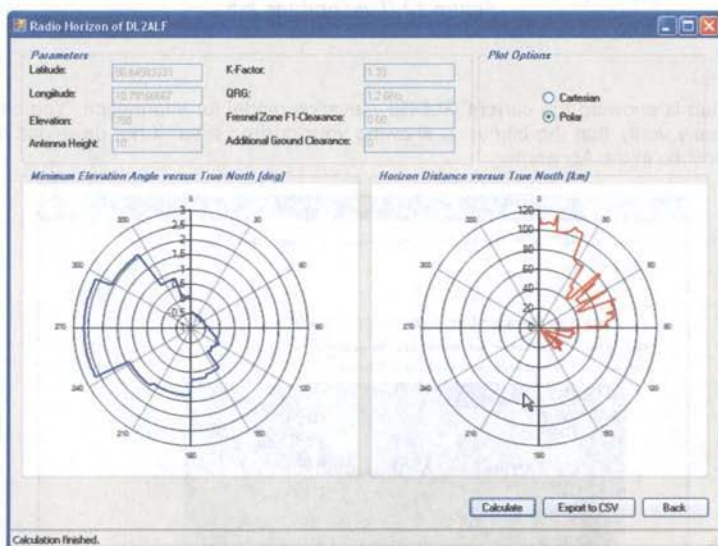


Figure 11: Station's radio horizon

Once calculated you can export the calculation to a CSV file by pressing the "Export to CSV" button.

Map

The "Map" tab contains basic settings for the map source and information shown on the main window.

Map Options

You can select different map sources here. This is a functionality of Great Maps library and not a part of AirScout itself. The default map source is OpenStreetMap. Some of the map sources may not be available for your area. Some of the map sources may be copyrighted or otherwise restricted in use. If you are choosing another map source than OpenStreetMap you will be asked to agree with the terms of use first.

CAUTION: The use of all map sources is at your own risk. The author will not be responsible for any copyright violation in any case.

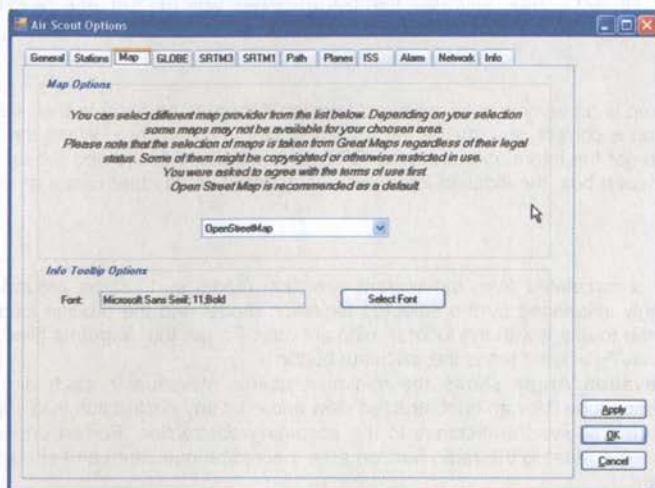


Figure 12: Map options tab

GLOBE

The "GLOBE" tab is showing the current GLOBE elevation model for information. You cannot alter any value here. Please verify that the bitmap is showing your desired area. If not download a new GLOBE data file as described in the Appendix.

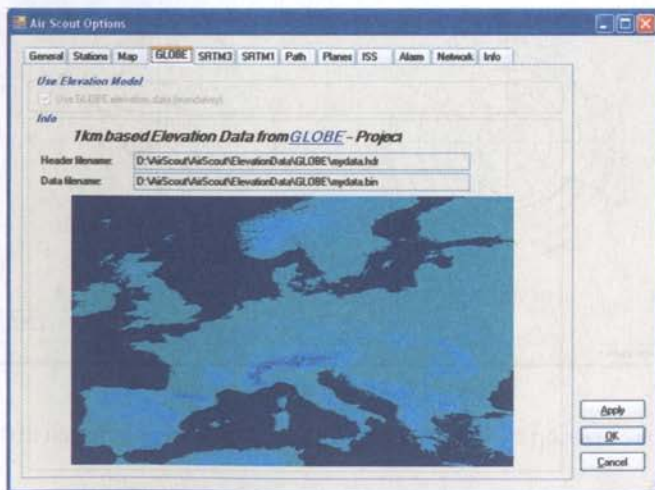


Figure 13: Globe tab

SRTM3

The "SRTM3" tab shows basic settings for the SRTM3 elevation model. You can use SRTM3 elevation data by checking the according check box. A map shows you the coverage of $1^\circ \times 1^\circ$ tiles found on your local storage. Check if the coverage fits to your desired covered area before using SRTM3 elevation data. If it is incomplete press the "Download data files" button to download the missing tiles automatically.

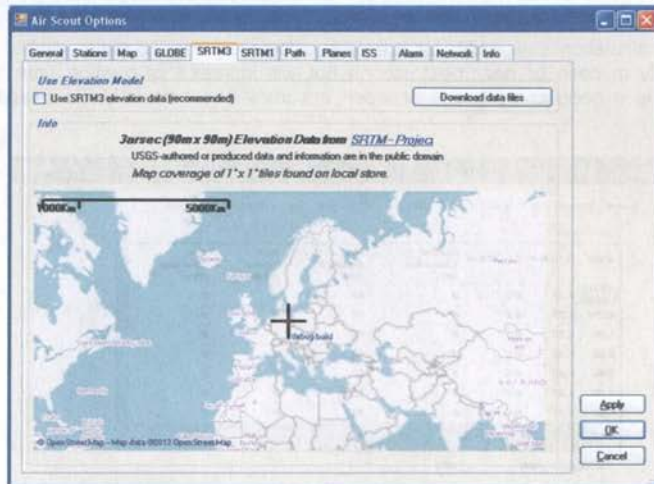


Figure 14: SRTM3 tab

SRTM1

The "SRTM1" tab shows basic settings for the SRTM1 elevation model. You can use SRTM1 elevation data by checking the corresponding check box. A map shows you the coverage of 1° x 1° tiles found on your local storage. Check if the coverage fits to your desired covered area before using SRTM1 elevation data. There is no automatic download available so far.

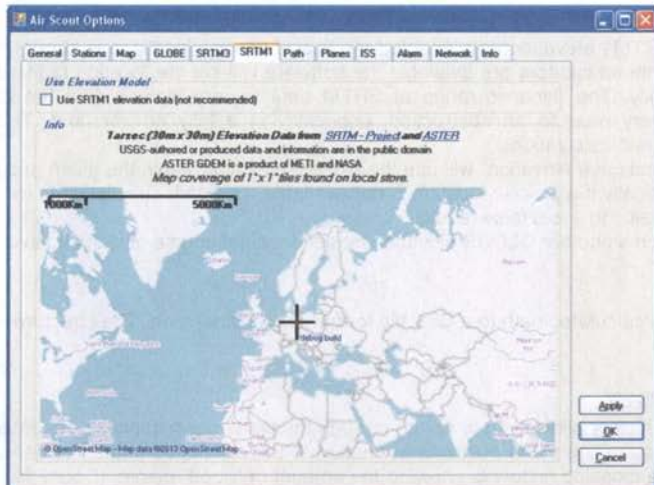


Figure 15: SRTM1 tab

Path

The "Path" tab shows currently selected path parameters. These can be set for each band separately. There are:

Path Options

Per band available set of path parameters as described in the section "Basic Parameters for Path Calculations".

Calculation Step Width

You can set the calculation step width for the path calculation here. Smaller values will increase the accuracy especially in case of near obstructions but will increase calculation time dramatically. The default of 1000m is a good compromise between accuracy and calculation time and will cover most cases.

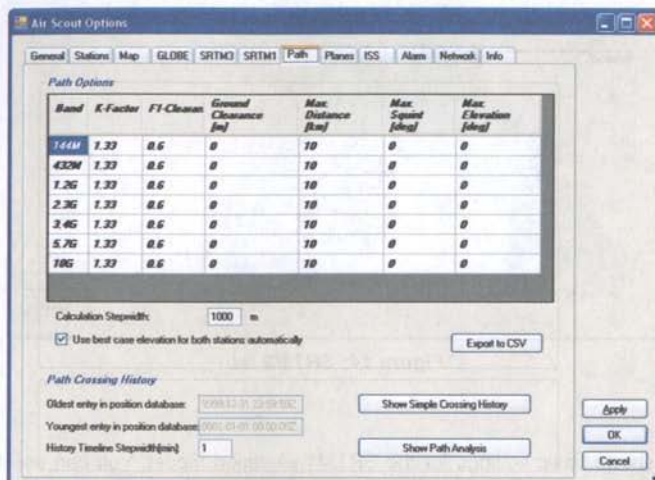


Figure 16: Path tab

Use Best Case Elevation

With SRTM3 or SRTM1 elevation data enabled the use of precise locations is strongly recommended. If only 6 digit Maidenhead locators are available the software will set the location to the centre of that grid square automatically. The dynamic range of SRTM data is very high so that the calculated centred location can be very near to an obstruction, especially in a hilly environment. This will result in a completely wrong path calculation!

The option "Use best case elevation" will use the highest elevation within the given grid square instead of the centre automatically if a precise location is not available. The path calculation is too optimistic then in most cases but it helps to avoid false results.

The use of the much smoother GLOBE elevation model does not course give such severe errors.

Export to CSV

You can export the calculated path to a CSV file for further consideration. The structure is described in the Appendix.

Path Crossing History

The path crossing history allows you to iterate through the plane position history recorded in the database and sets the corresponding plane positions in relation to the calculated path. The default step width is 1 minute. The simple crossing history is showing the amount of "good" planes (Count_Hi) and "bad" planes (Count_Lo) for each step in the given time span. This gives you an easy overview on which times AS is more likely than on others. The path analysis is showing a detailed path analysis in conjunction with an automated beacon monitoring system (e.g. PI4 with OZ7IGY). This function is still under construction and will be described later.

Planes

The "Planes" tab shows basic plane feeds and plane database options.

Plane Feeds

You can enable/disable Internet feeds here. Furthermore, multiple Internet feeds from different URLs with

different formats can be activated simultaneously. Do not change the URLs in the text boxes unless you know exactly what you are doing. Wait until an URL update is available via the Internet. Normally the simultaneous use of more than one stream produces best results. Anyway, sometimes inconsistencies between two feeds may occur and you will see doubled plane icons with slightly different positions or call signs. In this case, or to reduce network traffic, it is recommended to disable multiple feeds. One single feed will produce a traffic of about 1MB/min.

Plane Positions TTL

You can enter a plane positions "Time To Live" here. If the last position report is too old to estimate a current position the plane object is discarded and not used anymore. Set to 5 minutes by Default it is sometimes recommended to extend the time span. This will cause bigger estimation errors but is necessary when plane position reporting is delayed (e.g. by federal law in the U.S.).

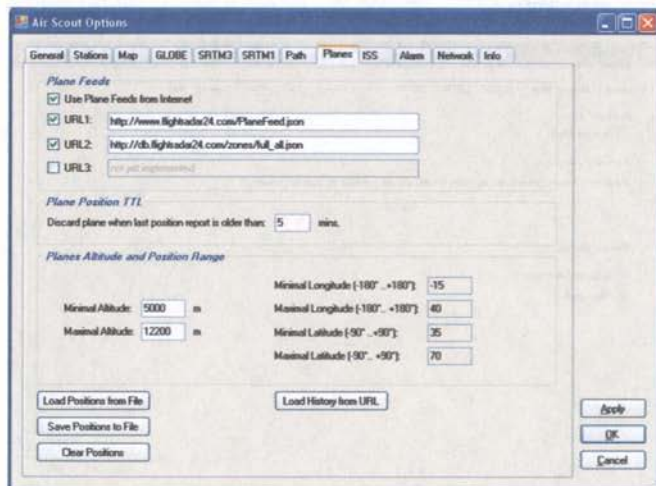


Figure 17: Planes tab

ISS

The "ISS" tab shows basic settings for drawing an ISS ground track.

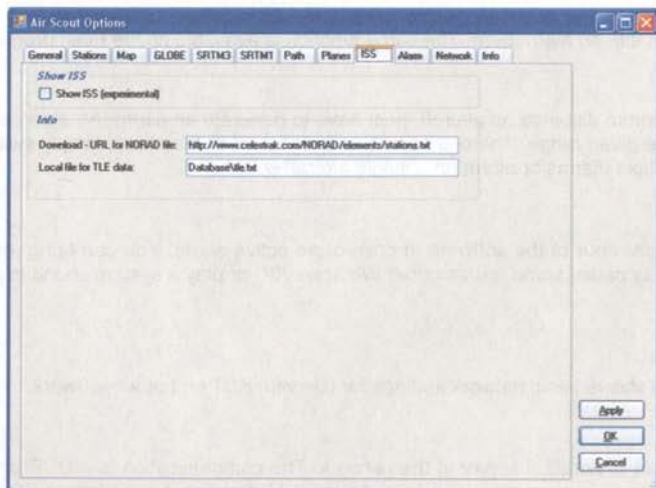


Figure 18: ISS tab

Show ISS (experimental)

You can enable/disable the display of an ISS ground track here.

Info

You can change the download URL and database file name for the TLE data here. The TLE information is downloaded on program start and kept in a local text file. Do not change the values unless you are an expert.

Alarm

The "Alarm" tab shows basic alarm settings. To generate an alarm, the software must be in "Run" mode and at last one action must be defined in "Alarm Settings". It is not possible to watch multiple paths to different QSO partners in background.

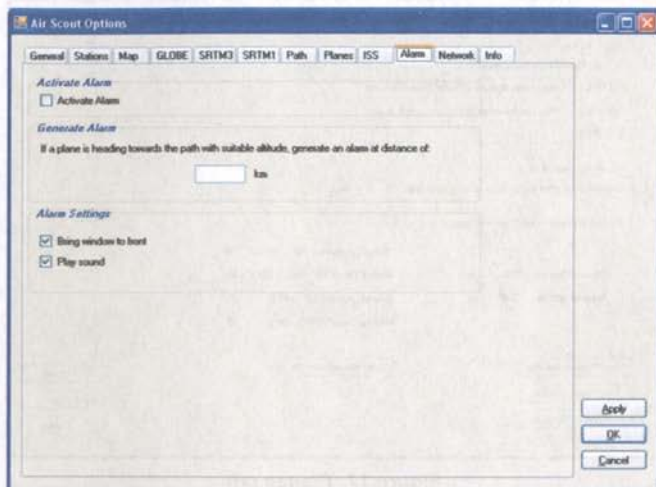


Figure 19: Alarm tab

Activate Alarm

You can enable/disable an alarm here. The same function is available on the main program window.

Generate Alarm

You can set a minimum distance an aircraft must have to generate an alarm. An alarm is generated if one aircraft is within the given range. There is no acknowledgement to the alarm; simply switch it off. AirScout cannot handle multiple alarms or alarm on a single aircraft so far.

Alarm Settings

You can set the behaviour of the software in case of an active alarm. You can bring the program's main window to front (may cause some issues under Windows XP) or play a system sound in an endless loop.

Network

The "Network" tab shows basic network settings for use with KST and other software.

Activate Server

This allows AirScout to act as a server in the network. The communication is a UDP broadcast similar to Win-Test contest logger communications (see Appendix for protocol description). You can have more than one server/client active in the same network.

Server Name

Set a unique server name here for your AirScout server. The name is used to identify different servers in the network. The name must match with all clients which want to communicate with a server.

Server Port

You can set the UDP port for broadcasting here. The port number must match with all participants in the network and must not collide with any other network communication. Do not change it unless you exactly know what you are doing here.

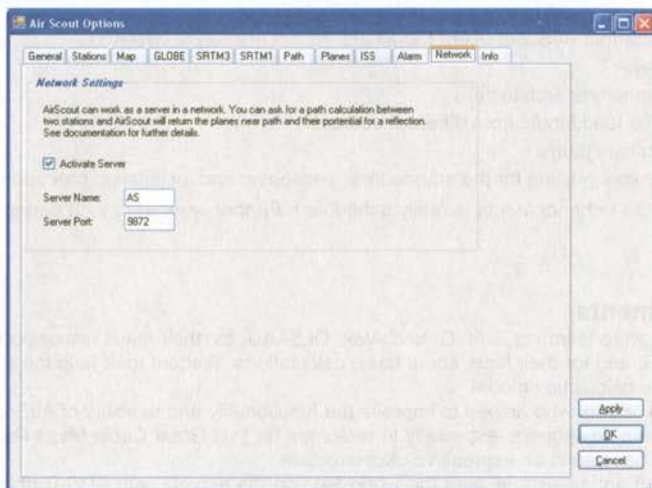


Figure 20: Network tab

Info

The "Info" tab shows program and version information, copyrights and acknowledgements.



Figure 21: Info tab

Future outlook

The AirScout software is currently in BETA status. It is not planned to release it until the end of 2013. There are some possible enhancements already identified:

- Include an antenna beam width (az/el) per band in calculations to get a maximum allowed elevation angle and limit the static distance from path with an maximum allowed azimuth angle
- Include a maximum squint angle per band in calculations
- Include 70 MHz
- A global server based database with station locations (other than QRZ.COM)
- An server based map to see who is online with AirScout
- An own chat within AirScout users (additional to, not instead of ON4KST)
- A history player
- Distinct client/server architecture
- Multiple plane feed inputs from different sources
- Watch of multiple paths
- Set up a network hosting for the source files, versioning and installation procedure

Currently, none of the enhancements is really scheduled. Further work will much depend on my personal time budget.

Acknowledgements

My special thanks go to Henning, DF9IC, and Alex, DL8AAU, for their initial discussions with me on the Aircraft Scatter topic and for their hints about basic calculations. Without their help the software would not have such a precise calculation model.

Thanks to all BETA testers who helped to improve the functionality and usability of AirScout.

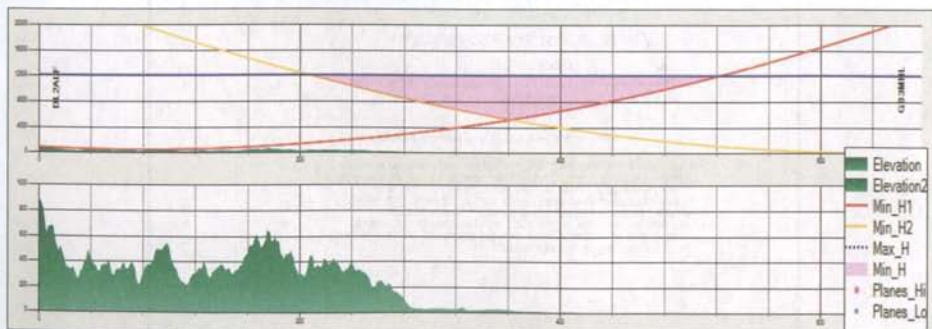
Thanks to all software developers, especially to *radioman* for that Great Circle Maps library, without them AirScout would not have such an expressive user interface.

Thanks to all aircraft enthusiasts all over the world feeding the servers with ADS-B data essential for the prediction and surveillance of aircraft scatter contacts.

And, last but not least, a big thankyou to all the airlines of the world, populating the sky with big aircraft making the basis for successful aircraft scatter operation.

References

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- [2] VK3HZ, Collection of Aircraft Enhancement Articles: www.vk3hz.net/ae.htm
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www.df9ic.de/doc/2006/sletten_2006/sletten06_airplane_reflection.ppt
- [4] Airscout Download: <http://www.dl0gth.de/software/airscout.zip>



Colour version, Figure 22: Example of a path calculation with „hot area“